POULTRY WATER QUALITY HANDBOOK

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Another New Venture for Southeastern Poultry & Egg Association

The environment and our natural resources form one of the cornerstones of our quality of life. Every industry, every company, every individual has a giant stake in the environment.

The poultry industry recognizes the significance of our natural resources and the importance of conservation and the protection of the environment. The growth and progress of the U.S. poultry industry have been phenomenal. However, rapid advancement has brought challenges that are often too complex to be solved easily or quickly. Answers are sometimes long-term and require deliberate, progressive action. Some solutions are environmentally related.

Southeastern Poultry & Egg Association understands the challenges that come with progress, particularly those that impact the environment. Industry leaders who make up Southeastern's Board of Directors, in yet another new Association venture, teamed up with key federal agencies — USDA Soil Conservation Service, Tennessee Valley Authority, and U.S. Environmental Protection Agency — to work on water quality issues related to the poultry industry. The Poultry Water Quality Consortium is a cooperative effort to identify and adopt environmentally prudent uses of poultry by-products. The objective: to use by-products as a resource.

However, success requires teamwork: the combined efforts of people and organizations, industry and government. No one is excluded from responsibility, not farmers, service providers, company management, or government officials.

This handbook is one part of a new and vital enterprise. The goal is to consolidate information, ideas, and references to enhance water quality. As this joint venture between industry and government continues, the handbook will be revised and updated to include new technology and techniques that will ensure the quality of water for everyone.

ACKNOWLEDGMENTS

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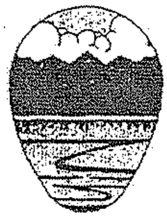

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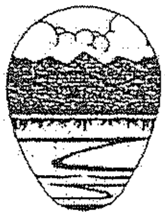

Poultry Environmental Issues and Impacts

In the United States, poultry is a major source of agricultural income. In 1992, the industry contributed over $12 billion to the economy of this nation. During the same period, U.S. exports exceeded 207 million pounds of poultry products, and U.S. per capita consumption of poultry reached 37.3 pounds per annum. Some 75,000 growers are involved in producing over 6.4 billion broilers, 269 million layers, 69 billion eggs, 285 million turkeys, and 20 million ducks; and recent estimates conclude that another half-million people are employed in hatcheries, live-bird processing plants, feed mills, and other allied operations serving the poultry industry. Both genetics and efficiency contribute to this magnitude of production.

These figures, which are projected to increase 5 percent each year into the future, are impressive; however, they also come with a yearly legacy of some 20 million tons of poultry manure and litter, over 50 million dead and unused carcasses, and over 50 billion gallons of water from hatchery, layer, and live-bird processing operations. These by-products must be safely disposed of or used. The challenge is where and how to use these poultry wastes to benefit the grower and the environment.

Traditional uses for poultry by-products are not always sufficient. Expanded or new uses for poultry waste have been found, such as enhanced fertilizers, horticultural and mushroom growing medium, and feed products for livestock, dogs, cats, and aquaculture. Indeed, a continuing search for additional uses is part of the challenge.

Protecting water quality, the environment, and the natural resources of this nation is a commitment of the poultry industry and growers. The industry shares responsibility with other segments of the agricultural community and other human activities for nonpoint source pollution: the pollution that originates from diffuse sources (e.g., stormwater runoff). Some industry practices could contribute to point source pollution: the pollution that issues from a known or direct discharge (e.g., from the end of a pipe).

One must understand the complexity of poultry operations when addressing water quality and environmental issues. The industry can be separated into hatchery, breeder, broiler-roaster-Cornish (meat types), turkey, egg, duck, and other poultry and live bird processing operations. Each of these operations produces either dry or liquid waste and dead birds. Environmental awareness has shifted beyond live-bird processing plants (offal, feathers, and wastewater) to the grower.

As any poultry grower knows, the speed, efficiency, and methods used to produce poultry and poultry products have changed drastically over the past 20 years. As a result of rapid growth, most poultry are grown in confined operations with limited use of water, except for drinking water for the birds. The expansion of the industry coupled with concentrating the growing operations has created a unique challenge — that of proper disposal of immense quantities of waste. It is important for producers and others to understand how poultry waste can pollute the environment. Each individual operation is different, yet many of the problems can be prevented or solved through proper waste disposal methods and changes in management and production methods during the production cycle.

OVERVIEW

It is important for producers to know (1) what is in the waste that must be disposed of; (2) how much waste is expected to be generated; (3) what are the impacts of the waste on water quality, the environment, and human health; (4) how these materials can get into the water; and (5) how to manage the waste in an environmentally safe manner.

The most overriding environmental issue facing growers today is the impact that poultry waste can have on water quality. Potential water pollutants from on-farm poultry operations can be classified as (1) nutrients and salts, (2) organic materials, (3) bacteria, and (4) viruses. These pollutants originate from manure and litter and dead birds improperly handled. How the waste is disposed of, treated, or managed has a direct influence on the cleanliness of surface and groundwater.

Properly managed poultry wastes from manure, litter, dead birds, and wastewater are profitable farm investments. An effective waste management plan provides for the proper collection, storage, handling, and use of poultry waste. Products derived from wastes reduce chemical fertilizer costs, improve soil quality, and protect water resources, air quality, and human and animal health. Effective waste management promotes a favorable public attitude toward the industry.

Disposing of dead birds is an increasing problem. Daily numbers and poundage of dead birds can be dictated by the birds' age and weight, the number of birds in the poultry house, and climatic conditions. Acceptable methods of disposal include (1) burial, (2) incineration, (3) composting, and (4) rendering. Burial pits may have severe environmental limitations in areas of porus or fractured soils that would allow leaching of nutrients to groundwater. Incineration has some limitations: the possibility of air pollution and fuel and labor costs.

Many progressive growers are switching to composting or to rendering as preferred solutions from an environmental and economic viewpoint. A grower must choose a method compatible with his or her individual opera-

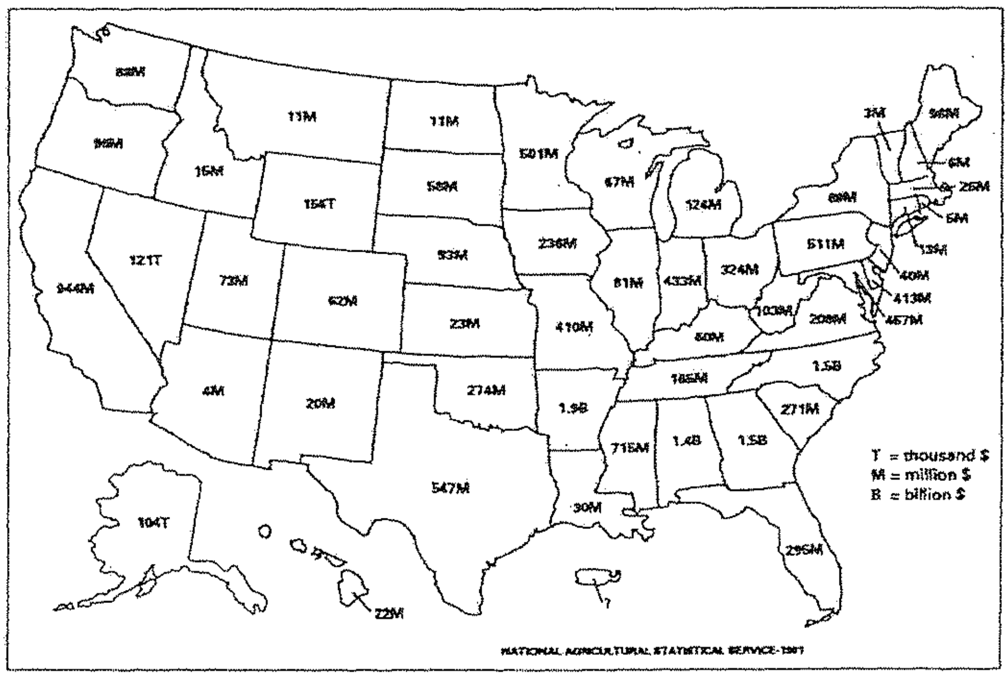

Figure 1.—Poultry cash receipts (in dollars).

OVERVIEW

tion and company preference. Dead birds must be treated as a resource that can add value to a grower's operation. Improper methods of disposal are unacceptable and cannot be condoned.

State regulations and permitting requirements vary from state to state and may be more stringent than national regulations. In general, environmental needs are site specific and regional in nature. Local sources of information, including industry associations, appropriate state agencies, soil and water conservation districts, and the USDA Soil Conservation and Cooperative Extension Service offices, should be consulted to ensure that your waste management plan complies with all state and federal regulations.

There is not a single best or optimal approach to protect or preserve water quality and the environment. Good waste management practices are essential if the poultry industry is to continue to grow and thrive under today's environmental challenges. The remainder of this handbook relates to the management of poultry wastes, mortalities, and wastewater. Information sheets on these topics provide management "guidance" to help poultry producers make sound environmental decisions; additional fact sheets discuss other environmental issues and alternative technologies, and sources of assistance are provided in the section on Resource Information (RI). Producers are encouraged to seek assistance from the appropriate state and federal agencies, private consultants, and other professionals on how to implement waste management techniques that protect water quality and the environment.

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Other pages in this handbook contain more detailed information on these subjects. Permission is hereby granted to producers, growers, and associations serving the poultry industry to reproduce this material for further distribution. The Poultry Water Quality Consortium is a cooperative effort of industry and government to identify and adopt prudent uses of poultry by-products that will preserve the quality of water for everyone. PWQ / 0 – 6/94

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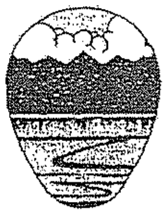

Protecting the Environment and Water Quality

Protecting natural resources is a major goal of the agricultural community in general, and poultry producers in particular, who care about the environment. The quality of our air, soil, and water resources, the welfare of our animals, and human health issues are important to us and to our children; they are our connection to the future. Water quality is the most important environmental concern of the poultry industry.

Environmental protection begins with awareness. We have to know what's at stake when we read or hear about water quality and conservation, or that high concentrations of nitrates or other contaminants have been found in surface and groundwater. We need to understand how the industry's waste management affects water quality. Above all, we must be able to assess the opportunities we have, as private producers and as an industry, to meet these environmental challenges head on.

Poultry growers and the industry must be concerned about the quality of water that comes into and flows from their farms or plants. The industry's first concerns are those that everyone shares: Does the water we use support our needs? Is it drinkable (potable) and palatable? What does it cost to supply water to our homes and businesses? Would additional costs for water treatment ensure its safety for our use?

Where the Water Is

Water covers 70 percent of the earth's surface, but only 3 percent of the earth's water is usable by plants, animals, and humans. Usable water exists either as surface water or groundwater. Surface water is the runoff that flows above ground through rivers, streams, and springs until it eventually drains into the sea or oceans. The land area that collects runoff in defined locations is called a watershed, and no matter how far one lives from the water, everyone lives in a watershed (see Fig. 1).

Groundwater is water that percolates through the soil or enters the earth's subsurface through sinkholes, permeable soils, and fractures in rock formations. The underground water formation is known as an aquifer within which the groundwater moves in various directions. Some aquifers are several hundred feet deep while others lie near the surface of the earth. The upper level of shallow aquifers is called the water table. It rises and falls depending on how dry or wet the season is, or how much groundwater is extracted for use.

Water is a renewable resource; therefore, surface and groundwater are constantly being replenished. But water can also be used up faster than it can be renewed or, in the case of groundwater, "recharged." Groundwater recharge is enhanced by limiting runoff. Human activities that speed runoff or add contaminates to surface and groundwater must be controlled. Land sediments, animal wastes, pesticides, detergents, oils, and grease are some of the human contributions to poor water quality.

Understanding Water Pollution

Strictly speaking, pure water does not exist. Even rainfall contains gases, dust, and ions acquired from the air. In fact, water (a molecule containing two hydrogen atoms and one oxygen atom) is a solvent; its ability to dissolve

WATER QUALITY ISSUES

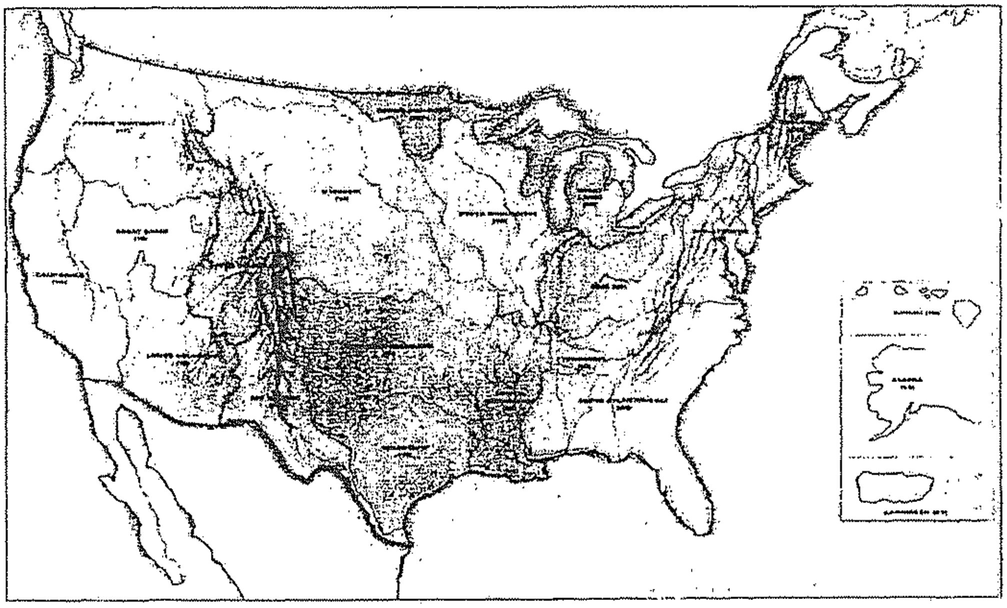

Figure 1.—U.S. Watershed Regions (Brown and Caldwell).

substances is essential to plant and animal life. Most of the substances, elements, or compounds that we think of as pollutants are also found naturally in water: nitrogen, phosphorus, potassium, calcium, magnesium, sodium, bicarbonate, chloride, sulfate, carbon dioxide, oxygen, and some heavy metals. But when one or more of these substances is found in excessive amounts, the water's use is impaired and the water may be considered polluted.

Potentially polluting substances, sometimes called dissolved substances or solids, can be organic or inorganic, and they occur in natural interaction among the elements of earth and sky. Their effects include color (or lack of clarity) and offensive taste and odor. They can be added to the water during industrial, agricultural, silvicultural, land development, or other activities that serve human needs and pleasures. In the poultry industry, for example, components of manure, dead birds, and wastewater include nutrients that may be released to water through direct discharge, excessive runoff from the land, or leaching through the soil.

We expect, then, to find some dissolved substances in water; however, water's properties are degraded — its quality impaired — if it contains chemical, biological, physical, or radiological substances in sufficient quantity to restrict its use. Water quality standards defined by the U.S. Environmental Protection Agency (EPA) identify what substances must not appear in water and at what concentrations other substances may be permissible under certain conditions. Tests or analyses performed on drinking water, surface, and groundwater illustrate the complexity of the issue.

✔ This information sheet has introduced the topic of water quality. Poultry growers and others should always check with local health agencies or state departments of environmental protection or similar agencies to ensure that they have access to current water quality criteria and standards applicable to their location. Water quality criteria are published in the Federal Register as they are developed.

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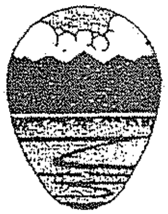

WHAT IS WATER QUALITY

Public domestic water supplies are regularly tested or analyzed for pollutants or contaminants. The results can be obtained from local health departments or appropriate state agencies. Private water supplies or wells should also be analyzed.

The most common tests for water quality analyze (1) pH (the level of hydrogen ions in the water), (2) total alkalinity, (3) total hardness, (4) salts, (5) chlorine, (6) dissolved oxygen, (7) metals, and (8) pathogens. Sometimes water needs to be tested for heavy metals, such as lead, mercury, or zinc; or for toxins, such as DDT or Atrazine. In some areas of the country, tests for radiological contaminants may be needed. The following parameters are used to test water's chemical properties.

- The measure of pH in water determines its acidic or alkaline quality on a relative scale. (For example, in a solution of hydrochloric acid, the pH is 3; for sodium hydroxide, it is 12.) In water, on a scale from 0 to 14, a pH measure of 7 is neutral; for drinking water for humans and animals, the desirable measure of pH is 6.5 to 8.

- The total alkalinity of water is a measure of its capacity to neutralize acidity, which is usually expressed in milligrams per liter of calcium carbonate (mg/L of $CaCO_3$). Natural waters may have less than 50 or as many as 500 mg/L of $CaCO_3$). These variations may be affected by the rocks and soils that the water passes through. The alkalinity varies with pH and hardness, but sudden fluctuations may indicate a contaminant.

- Water also contains total dissolved solids (TDS) and minerals. TDS represent the soluble mineral or salt content of water, especially calcium, magnesium, sodium, chloride, sulfate, bicarbonate, and silica. These substances, if excessive, can affect industrial processes, and their presence in water is frequently associated with discharge from industrial operations. TDS also affect the germination and growth of plants and the palatability of drinking water. Some minerals are desirable for their beneficial properties. Drinking water should not have more than 500 mg/L of TDS and irrigation waters may have up to 1,500 mg/L of soluble minerals.

  Hard waters contain so much calcium and magnesium that it is difficult to make soaps lather. When heated, hard water forms scale or deposits that we see on cooking utensils and water pipes. Water softening solves the hard water problem but may increase the amount of sodium in the water — a possible danger to people on low sodium diets. Sodium in drinking water should be limited to about 20 mg/L.

  Total iron (suspended and dissolved) causes problems in water if it exceeds 0.3 mg/L. High iron levels impart a reddish brown color to water or a bad taste to cooked foods and may restrict growth in turkeys.

  Chlorides in water should not exceed 250 mg/L; otherwise, the water may have a salty taste. High chlorides may also indicate pollution from sewage or other sources.

  Sulfates, which should not exceed 250 mg/L, are caused by the leaching of natural deposits of magnesium sulfate

(Epsom salts) or sodium sulfate (Glauber's salt). These salts are undesirable because of their laxative effects.

Nitrates (NO_3-) and nitrites (NO_2-) pose health problems to animals and humans, including poultry. Their presence in surface or groundwater in large amounts may indicate that someone has over-fertilized a field or allowed a septic tank system failure. Nitrate levels in drinking water should not exceed 10 mg/L; and nitrites, which convert to nitrates, should not exceed 1 mg/L.

- Chlorine gas and other chlorine compounds are powerful disinfectants and oxidizing agents. Chlorine should be limited in drinking water to no more than 0.05 mg/L; however, there must be a small chlorine residual in drinking water to assure that it is disinfected.

- Dissolved oxygen (DO), which is vital for aquatic life, can be a key test for water pollution. At DO levels below 3 mg/L, fish may become stressed or die. Generally, in unimpaired waters, dissolved oxygen ranges from 7 to 14 mg/L. However, DO levels approaching 14 mg/L on sunny days may indicate high density algae growth and possible nutrient enrichment (pollution).

Usually, among these parameters, only pH, total iron, DO, and nitrates/nitrites have reference to poultry. Nevertheless, careful and complete monitoring of private water supplies and wells is a must because they provide drinking water for home and poultry operations. When the chemical properties of water exceed acceptable limits for intended uses, water quality is impaired.

Biological Properties

Private water supplies should also be tested once or twice a year for any sign of coliform bacteria. The test for fecal coliform bacteria can differentiate between the bacteria found in soils and plants and the bacteria found in warmblooded animals. Common symptoms of coliform bacteria in humans are intestinal bloating and diarrhea.

Other bacteriological tests can identify many kinds and numbers of bacteria in water, but they do not separate harmful and harmless bacteria. Tests for Fecal Streptococci, Shigella, Salmonella, Staphylococci, and other bacteria may be necessary under certain circumstances. These tests are specific, time-consuming, and expensive. They isolate bacteria that cause typhoid fever, eye and ear infections, dysentery, boils, or other skin diseases. There are also tests for viruses, protozoa, and parasites.

In surface waters, aquatic vegetation and microscopic animal and plant life may be stimulated or retarded by various water quality factors — pH, nutrients (nitrogen and phosphorus), and turbidity, among others. But growth and decay cycles may have side effects that adversely affect the water quality. Even helpful substances can become harmful in overabundance; for example, organic nitrogen in animal wastes and soils can cause "nutrient loading," which results in low DO levels and eutrophication (i.e., an overly productive waterbody.)

Physical Properties

Physical characteristics of water include turbidity, color, tastes, odors, and temperature. The presence of foam is an indicator of dissolved organic substances, perhaps raw sewage. Suspended particles may cloud the water, and dissolved substances may alter its odor or taste. Turbidity or cloudy water may indicate the presence of sediments, which reduce light penetration. Color affects quality and can be aesthetically displeasing. Taste and odors can result from dissolved metals, gases, or chemicals.

Radiological Properties

Some radioactivity in water, food, and air is natural. However, if higher levels than usual are suspected, the appropriate state agencies should be notified.

Without efficient management of poultry waste and dead birds, poultry operations could become a source of excess nutrients, disease-causing bacteria or viruses, and dissolved substances in our nation's surface and groundwater supplies. Proper waste management will enhance the quality of water for everyone.

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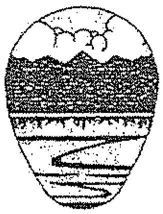

Poultry Production and Water Quality

Every year, the poultry industry produces about 20 million tons of manure/litter, 50 million tons of dead birds, and 46 billion gallons of wastewater. What happens to these by-products can be good or bad for the industry and for the environment.

On the one hand, poultry wastes can do a lot of good. They can be used as fertilizer, soil enhancers, cattle feed, or energy. Poultry producers can add value to these products — and prevent them from contaminating surface and groundwater — by using proven, acceptable methods of collection, storage, handling, disposal, and management. All such beneficial uses depend on proper management. Without such management, the value of the waste rapidly declines, resulting in its greater potential for adversely affecting the environment and water quality.

To control and prevent pollution, poultry growers need to understand how these values can be enhanced and maintained and how the wastes may contribute to point and nonpoint source pollution. The value in poultry by-products and their potential to cause water pollution have the same source. That is, the wastes and dead birds contain elements of the following categories: nutrients and salts, suspended materials, products of biological reactions, and microorganisms. These elements can be beneficial to the grower and other farmers, or they can be harmful to the environment.

Nutrients and Salts

Poultry manure is a valuable nutrient for grain and fiber crops, forage crops, fruits, and vegetables. However, if manure, litter, dead birds, and/or wastewater are not properly protected, water contamination can occur from the premature release of nitrogen and phosphorus into the environment.

Nitrogen is an essential plant nutrient but, in excess, it can be harmful. High concentrations of nitrate (dissolved nitrogen) in drinking water can affect human health, especially in infants and children. Ammonia in small quantities is toxic to fish and aquatic organisms.

When nitrogen and phosphorus concentrations in waterbodies rise too high, algae and rooted aquatic plants take over, prematurely aging and choking the waterbody and creating undesirable conditions — odors, offensive taste, and discoloration — all of which can make the water unfit for consumption or recreational and aesthetic use. Further, these eutrophic conditions can kill fish, clog water treatment plant filters, and lead to the growth of blue-green algae, a species that can be fatal to livestock.

Because nitrate-nitrogen is highly mobile, it can leach into groundwater and flow with stormwater runoff into surface waters. If too much poultry manure and litter are used as fertilizer, nitrogen and phosphorus concentrations in nearby waters are likely to be high. Soil erosion also increases the amount of phosphorus in surface waters. Excessive phosphorus in soil, above 800 mg/L, may become soluble and move into groundwater.

Calcium and sodium salts are added to poultry feeds to help the birds maintain chemical balance and nutrition. Excess salts pass through the animals and are eliminated in manure. Sometimes, when the waste accumulates, the salts leach into groundwater and enter surface water through unprotected runoff. There they alter the water's taste or harm freshwater plants and animals.

Suspended Materials

When suspended matter from poultry wastes reach surface water, the waterbody not only looks unattractive — the quality of the water invariably suffers. The suspended material reduces the penetration of sunlight and therefore slows the production of oxygen. The result is an oxygen demand that reduces the levels of dissolved oxygen in the water. It also clogs fish gills, makes it difficult for sight-feeding fish to find food, and settles over fish spawning areas.

Products of Biological Reactions

In a natural environment, the breakdown of organic matter, such as poultry waste, is a function of complex, interrelated, and mixed biological populations. All substances of animal or vegetable origin contain carbon and are, therefore, organic. Organic matter is converted to simple compounds by naturally occurring microorganisms. These simple compounds may be other forms of organic matter or they may be nonorganic compounds or gases, such as nitrates, orthophosphates, ammonia, and hydrogen sulfide. A biological reaction occurs when manure or other organic matter is added to water and aerobic organisms (oxygen requiring organisms) begin the decaying process. The bacteria consume free oxygen and produce carbon dioxide gas. Under anaerobic conditions (without oxygen), methane, amines, and sulfides are produced.

Microorganisms

Desirable and undesirable microorganisms live in our environment. Animal waste is a potential source of some 150 disease-causing organisms or pathogens. These organisms include bacteria, viruses, fungi, protozoa, and parasites. Examples of undesirable microorganisms include Salmonella, Listeria, coliform, New Castle (virus), ringworm, coccidiosis, and Ascaris.

When found in water or wastes, these pathogens pose significant threats to humans and other animals. They can infect humans and animals through drinking water, contact with the skin, or consumption of fish or other aquatic animals.

Most pathogens die relatively quickly. However, under the right conditions, they can live long enough to cause problems. They may persist longer in groundwater than in surface water.

✔ Producers can prevent poultry by-products or waste from contaminating water. However, environmental needs are site specific and regional in nature. In some cases, state regulations and permitting requirements may be more stringent than federal regulations. Therefore, local sources of information, including industry associations, state departments of environmental protection and public health, and USDA Soil Conservation Service and Cooperative Extension Service offices should be consulted about poultry waste or by-products that affect water quality.

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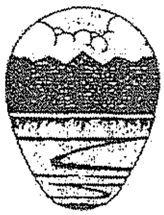

Understanding Water Quality Regulations

As the poultry industry grows, so does concern for water quality, conservation, and management of our natural resources. Growers have individual and civic reasons for caring: you are responsible, with other human beings, for the earth's environment and — more personally — you realize that you, your families, and neighbors all drink the same water. Pollution is intolerable whether it is detected in your own land and water, or after it has traveled many miles downstream from the source. The arithmetic is simple: good environmental stewardship reduces the costs of production, reduces water pollution, saves natural resources, and makes good neighbors.

Changing Attitudes

It is important to note that most federal regulations are delegated to states. In some few cases, double jeopardy may exist — the effect of combined federal and state regulations. Because states monitor water quality resources, poultry owners must check with state and local agencies before setting up compliance programs. Often the states are more stringent than federal enforcement requires. Engineering and government consultants can help growers know, understand, and comply with the regulations in their area.

Reasons to change personal attitudes toward water use and conservation have less to do with regulation than with management. Growers want a good public image, cost reductions, efficiency, and compliance. Most operations have discovered a workable slogan and a reasonable directive in "pollution prevention pays." Making pollution prevention changes can bring a big return on investment; however, they should also be made with an eye on the best ways to protect the environment. For example, we should

- prevent the generation of wastes where possible;
- recycle wastes that cannot be prevented;
- pretreat wastes to eliminate possible contaminants; and
- dispose of unusable wastes properly as a last resort.

Water quality concerns for the poultry industry include

- protection of water quality through management of soil erosion, waste, nutrients, and pesticides;
- the continuing availability of water in sufficient quantities for washing, making brine, cooking, cooling, cleaning, processing, conveying, and sanitation; and
- the safe disposal and use of wastewater and other wastes.

Management commitment and awareness, scientific research and common sense, and in some cases, new installations and equipment are needed to protect the availability and quantity of our natural resources. The scope of the problem is global, national, and industry-wide; cooperation among agencies, associations, and individuals speeds the development of technology and its transfer, and creates a participatory environment that encourages the search for solutions.

Difficulties encountered in the 1950s and 1960s often resulted from an absence of water quality standards and confusing, contradictory, or nonexistent national effluent limitations. These difficulties have been remedied by national legislation and regulations that are often administered by the states. Federal legislation for controlling water pollution that has developed over the past two decades illustrates the national commitment to develop and implement a strategy that will lead to cleaner air and water.

Point and Nonpoint Source Pollution

For best management, water pollution sources are divided into two groups depending on their point of release. Point source pollution has a known origin, such as a pipe or storage tank. Nonpoint sources of pollution are dispersed, harder to pinpoint, and cumulative. They include land uses, such as human activities, that are potentially significant because they occur in high densities. Agriculture, mining, forestry, septic and other waste disposal systems, and urban runoff are examples of nonpoint source pollution.

Poultry growers must know how to manage point and nonpoint sources because waste handling and disposal may contribute to nonpoint sources of pollution; while concentrated animal feeding operations (CAFOs), including some large poultry houses, are regulated as point sources of pollution. Federal law generally forbids point source discharges, that is, the discharge of any pollutant or contaminate to "waters of the United States." States administer the federally mandated National Pollutant Discharge Elimination System (NPDES) program. This program requires dischargers to have an operating permit before discharging potentially contaminated wastewater into streams, ponds, waterways, sinkholes, drainage ditches, or groundwater.

Practices that protect surface water include diverting off-site drainage around the feeding facility and constructing storage for manure and process-generated wastewater. Adequate runoff storage should be included in the design. Lagoons or holding ponds should be built to hold a 25-year, 24-hour duration storm.

Managing Nonpoint Source Pollution

The extent and importance of nonpoint sources have been more fully realized in the last decade. But nonpoint sources are so diffuse that they are usually assessed locally on a stream-by-stream basis and controlled by best management practices (BMPs). BMPs are routine methods of animal and crop farming that also control stormwater. That is, they are farming methods that control or eliminate the potentially harmful effects of agriculture on runoff.

Compliance Issues

Water quality legislation has teeth. Section 309 of the Clean Water Act establishes criminal penalties for failure to comply with the regulations. The threat of prosecution can be a first step in forcing compliance; the charges can range from minor infringements or negligent actions (lightly punished) to more serious charges of conscious violations and knowing endangerment. Knowing and willful endangerment and outright falsification are the most serious charges.

In short, point source wastewaters that leave a poultry house or plant must comply with the national effluent levels. A pretreatment program may be necessary. Some poultry operations have discovered that running their own pretreatment plants, though expensive, can be more efficient than other methods of compliance.

The U.S. Environmental Protection Agency now uses audits to determine how and why publicly owned treatment works are not in compliance. Recent regulations (in 40 C.R.F. Part 403) concern pretreatment:

- Pollutants that would interfere with the operation of the publicly owned treatment works or cause fire or explosive hazards are not permitted.
- No pH levels lower than 5.0 are allowed.
- Solid or viscous pollutants are monitored.

- High levels of biological oxygen demanding substances (BOD) are regulated as are oils, grease, and toxic gases.

The poultry industry should, therefore, take an active part in pretreatment programs.

Current Developments

The Clean Water Act was amended in 1987 and is scheduled for further amendment and reauthorization in 1994 or 1995. The original legislation (and NPDES program) was mainly concerned with industrial wastes; the later amendments have placed, and will continue to place, more emphasis on controlling nonpoint sources of pollution (urban and agricultural runoff).

Since 1987, nonpoint source pollution has been recognized as a major contributor to surface and groundwater contamination. In addition, permits have been required since 1972 for concentrated animal feeding operations.

Poultry growers and processors should be concerned beyond the short-term availability of water resources. But a change in our attitude about water use depends on cooperation, knowledge, and commitment to quality, efficiency, and environmental protection.

✔ Federal regulations are administered in most cases by the states, whose regulations and permitting requirements vary and may be more stringent than national regulations. Please consult local sources of information, including industry associations, state departments of environmental protection and public health, and USDA Soil Conservation Service and Cooperative Extension Service offices, to ensure that your waste management activities comply with all regulations and ordinances.

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Environmental Impacts of Poultry Waste

Agricultural activities, including the production of poultry wastes, may be increasingly responsible for contributing excess nutrients (especially nitrogen and phosphorus) to our water resources. Nutrient management planning in conjunction with land applications can reduce or eliminate this excess and contribute to more productive farming by helping farmers apply only as much nutrient to the soil as the plants can use. Most problems can be controlled if the grower knows how nutrients and soil interact and plans accordingly.

Nitrogen, phosphorus, and potassium move through cycles on a farm. As nutrients, they go from crops to animals (in feed) to the soil (waste applications) and back again to other crops. If the cycle holds, everything works as it should. But if too many of these nutrients are already in the soil or too much waste is applied to the land, they can move with the soil into surface water or through the soil into groundwater until their presence in the water reaches unacceptable levels, that is, is sufficient to impair water quality.

Nitrogen

Of the three major nutrients in poultry waste, nitrogen is the most complex and likely to contribute to environmental problems. Most of earth's nitrogen exists as nitrogen gas in the atmosphere (see Fig. 1). It can be transformed into inorganic forms by lightning or into organic forms by plants, such as soybeans, alfalfa, or clovers. Nitrogen can also be transformed into inorganic forms (commercial fertilizers) by energy intensive processes.

Most of the nitrogen found in animal wastes is organic nitrogen. A smaller amount of the nitrogen in litter is ammonium. Organic nitrogen can be mineralized or converted by soil bacteria into inorganic nitrogen, the form in which nitrogen is available to plants. Excessive organic and ammonium forms of nitrogen are transformed in the soil into nitrate nitrogen (that is, into water soluble nitrogen).

Losses of nitrogen from the cropping system can occur as a result of surface runoff and leaching. Surface runoff can move dissolved nitrogen (especially nitrate), ammonium nitrogen attached to eroding soil particles, and organic nitrogen contained in organic or plant residues into streams and lakes. Nitrates move with the soil or leach through well-drained soils past the root zone into the groundwater supply.

High levels of nitrate can be toxic to human health, especially newborns. Nitrate can reduce the blood's capacity to carry oxygen or cause internal suffocation. Scientists tell us that too much nitrate can affect the weight, feed conversion, and performance of poultry. Too much nitrogen in surface water can kill fish and cause the water to be less productive.

Phosphorus

Poultry wastes also contain significant amounts of phosphorus (Fig. 2). Phosphorus, like nitrogen, is essential for plant and animal growth; however, if it is used improperly, phosphorus can also contribute to environmental and water quality problems. It can be a major cause of water quality degradation in surface waters.

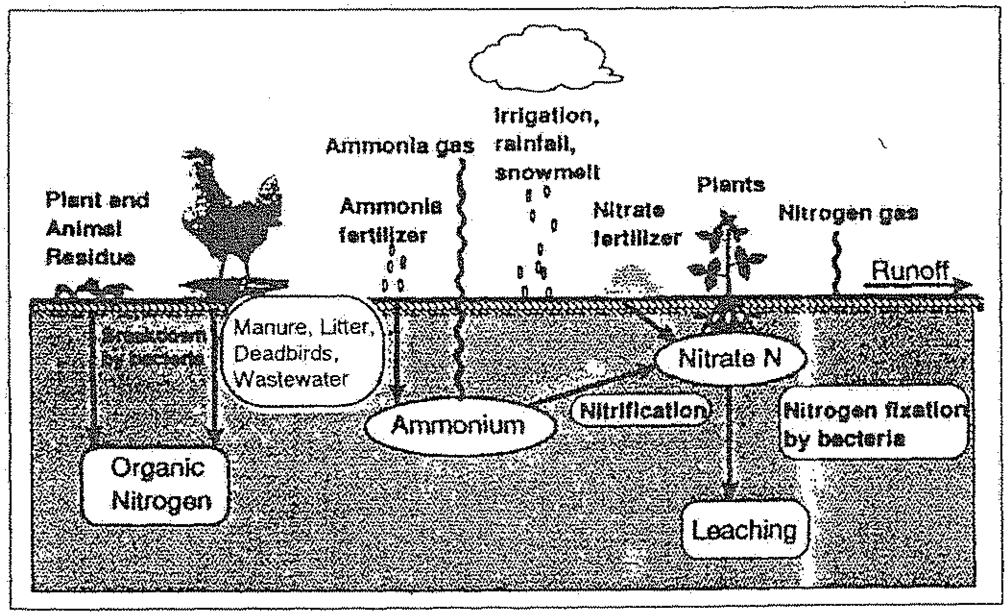


Figure 1.—The nitrogen cycle.

Phosphorus exists in either dissolved or solid form. Dissolved phosphorus usually exists as orthophosphates, inorganic polyphosphates, and organic phosphorus in the soil. Phosphorus in the solid form is referred to as particulate phosphorus and may be composed of many chemical forms. Particulate phosphorus comes in four classifications:

- adsorbed phosphorus, which attaches to soil particles;
- organic phosphorus, which is found in dead and living materials;
- precipitate phosphorus, which is mainly fertilizer that has reacted with calcium, aluminum, and iron in the soil; and
- mineral phosphorus, the phosphorus in various soil minerals.

Approximately two-thirds of the total phosphorus in soil is inorganic phosphorus; the remaining one-third is organic. Both forms are involved in transformations that release water-soluble phosphorus (which can be used by plants) from solid forms, and vice versa.

Phosphorus-laden soil moves via runoff into rivers, lakes, and streams, where it can cause excessive plant and algae growth, which in turn depletes the dissolved oxygen content in the water. Phosphorus-enriched waters contribute to fish kills and the premature aging of the waterbody. In the end, the beauty and use of the waters are seriously curtailed. Even relatively small soil losses may result in significant runoff leading to high nutrient depositions in the water.

Controlling soil erosion and proper land application of phosphorus-containing wastes will greatly reduce the amount of phosphorus in water. Care must also be taken to prevent soluble phosphorus from leaching into groundwater.

Applying poultry waste to the land at rates based on supplying the nitrogen needs of grain or cereal crops can lead to a phosphorus buildup in the soil. Planting forage crops in rotation with grain crops will help remove excess phosphorus. Maintaining soil pH at the recommended level is also an effective and economi-

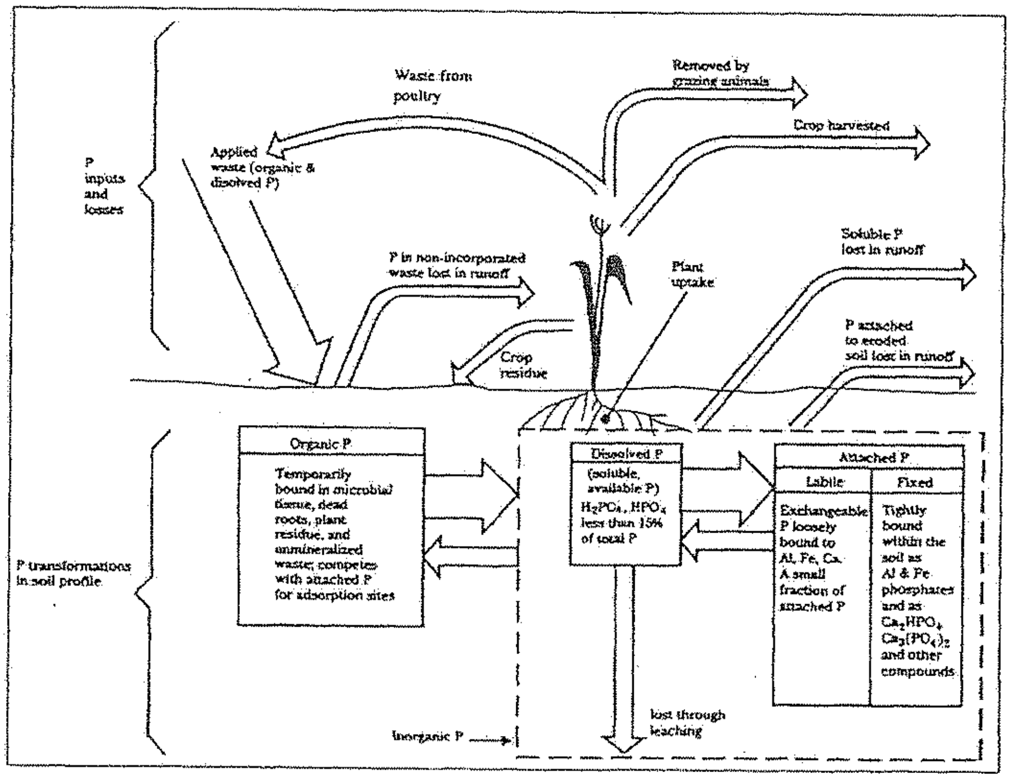


Figure 2.—Abbreviated phosphorus cycle.

cal practice for maximizing phosphorus efficiency. Crops use phosphorus most efficiently when the soil pH is between 6.0 and 7.0.

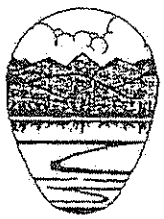
Soil phosphate levels are an important consideration in calculating poultry litter application rates. Land applications should be made only to soils that do not already contain excessive phosphate levels. An analysis or test should be conducted on each waste source prior to land application to determine proper phosphorus application rates.

Potassium

Potassium in poultry waste is a soluble nutrient equivalent to fertilizer potassium. (Excreted as uric acid, it is combined with the feces, and referred to as excreta.) It is immediately available to plants when it is applied. Potassium is fairly mobile but does remain in the soil to help supply plant needs, for example, strong stems, resistance to disease, and the formation and transfer of starches, sugars, and oils. Excessive amounts of potassium can inhibit or restrict the growth of some plants at certain stages of development. Small amounts of potassium may be leached to groundwater, especially in sandy soils; however, potassium or potash is usually not a threat to water quality or considered a pollutant.

Heavy Metals and Trace Elements

Heavy metals and trace elements, such as copper, selenium, nickel, lead, and zinc, are strongly adsorbed to clay soils or complexed (chelated) with soil organic matter, which reduces their potential for contaminating groundwater. However, excessive applications of organic waste containing high amounts of heavy metals or trace elements can exceed the adsorptive capacity of the soil and increase the potential for groundwater contamination.



Planning Poultry Waste Management

Developments within the poultry industry, changes in land use patterns, and increasing restrictions or regulations on the disposal of poultry waste have significantly altered the industry's attitudes about this immense resource. Over 50 million tons of poultry waste are produced each year. Because production is concentrated in very small geographic areas, waste management planning is extremely important.

Historically, poultry growers applied poultry waste to their farms as much to dispose of the material as to use it for fertilizer. Difficulties with this practice increase with the supply for several reasons:

- Less cropland is farmed today than 20 years ago, and more poultry operations exist today.
- Other resources (wastewater, composted residential waste, and sludge) are also being used for land applications, which increases competition for the remaining croplands and pastures.
- We know now that valuable nutrients — nitrogen, phosphorus, and potassium — are squandered and water resources are threatened if land applications of waste are overdone or misapplied.
- Regulations regarding waste management are now enforced by many states.

Concern for water quality has been a major catalyst for the upsurge of interest in new approaches to land application. Today's growers are finding that poultry waste planning increases farm production, protects the environment, and lowers costs.

An Integrated Approach

Traditionally, poultry growers have efficiently disposed of these wastes as soon as possible by spreading the manure or litter on croplands or pasture. Now growers plan for its ultimate use, and waste management begins inside the poultry house. Along with the grower's objectives, for example, flock health, production, and odor control; today's waste management planning must also protect water quality and contribute to a profitable farm operation. Integrating these broad objectives requires many growers to develop other options in addition to land application.

Thus, to be profitable and to protect our natural resources — air, soil, water, plants, and animals — poultry growers must plan their waste management practices carefully. They must base application rates and timing on soil test results and crop removal needs along with an analysis or estimate of the nutrients contained in the manure or litter.

Poultry waste management planning begins before actual production and may have as many as six steps or functions (Fig. 1).

The first step is to understand the waste management process. What are these wastes? How much does a particular operation produce on an annual basis? Where or how can these wastes be used? The second step, once the quantity and quality of the wastes have been determined, is to put efficient collection methods in place.

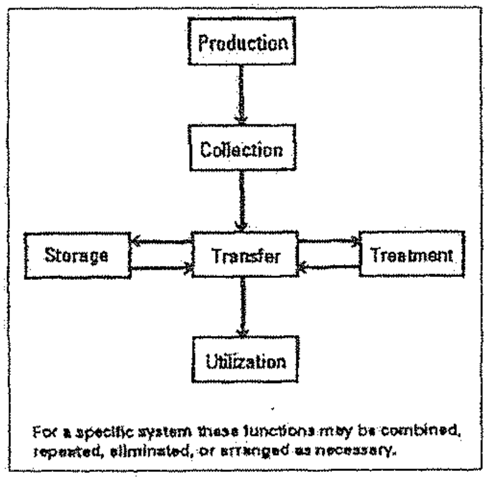


Figure 1.—Steps in an animal waste management planning system.

The third and fourth steps are to have adequate storage facilities and the ability to transfer or move the waste from the point of collection to the appropriate point of use. In some cases, a fifth step is included to determine whether biological, physical, or chemical treatment of the wastes is needed to reduce the potential for pollution or to prepare the wastes for final use.

The sixth and final step in the waste management plan is to use the wastes — normally, for land application as a fertilizer and soil improvement or as a feed ingredient — in accordance with the nutrient management plan. Growers will usually have identified sufficient land on which to apply the waste before production begins. If enough land does not exist, other uses must be assigned or additional lands located for disposal.

The Benefits of Nutrient Management

Nutrient management planning begins when the poultry waste management plan has proceeded from conservation and protection to the actual use of these products for land applications or energy and feed production. Nutrient management planning matches the nutritional requirements of the soils, crops, or other living things with the nutrients available in the manure or litter, thereby preventing nutrient imbalances, health risks, and surface and groundwater contamination.

Nutrient management recognizes the nitrogen, phosphorus, and potassium content of poultry waste, which is its value; and increases this value by matching the nutrients available in the resource with the nutrients needed in the application. This planning also reduces disposal and handling costs. Nutrient management planning makes it possible to use poultry manure to replace commercial fertilizers or at least to reduce their use — thereby reducing the costs of nutrients associated with crop production. Nutrient management also minimizes the potential harmful effects that overapplication can have on the environment.

An essential goal of nutrient management is to make sure that any poultry waste, especially manure or litter, is used safely and effectively. Nutrient management is, in fact, the key to using this waste as a beneficial by-product. To obtain maximum benefit and prevent possible contamination of surface and groundwater, the following management principles and practices can be applied:

- Develop and apply a Resource Management System, an Animal Waste Management System, a Nutrient Management Plan, or similar program. Assistance is available from the local offices of the U.S. Department of Agriculture's Soil Conservation Service, the Cooperative Extension Service, or state departments of agriculture.
- Find out if your state uses nitrogen as a basis for land application requirements. If not, is phosphorus a concern in your area?
- Analyze poultry waste regularly to monitor major nutrients and pH levels. Proper soil pH will help maximize crop yields, increase nutrient use, and promote decomposition of organic matter.
- Apply only as much fertilizer (nutrients) as the crop can use.
- Calibrate equipment and apply waste uniformly.
- Incorporate poultry waste into the soil if possible to reduce runoff, volatilization, and odor problems.

- Do not spread poultry waste on soils that are frozen or subject to flooding, erosion, or rapid runoff prior to crop use.
- Spread poultry waste during specific growing seasons or as scheduled for maximum plant uptake and to minimize runoff and leaching.
- Use proper storage methods prior to land application.
- Maintain a vegetative buffer zone between the field of application and adjacent streams, ponds, lakes, sinkholes, and wells.
- Follow approved conservation practices in all fields.
- Be considerate of neighbors and minimize conflicts when transporting or land-applying poultry waste.

Training, technical assistance, and in some cases, financial aid are available to help growers and crop farmers identify problems and develop solutions for using poultry waste in their specific regions. The Soil Conservation Service and Cooperative Extension Service, for example, have developed work sheets for animal waste management systems that will help growers make production estimates, obtain soil and manure analyses, and make economical and practical use of the organic resources generated on the farm. These agencies and others can help growers design facilities and develop overall resource management plans.

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Other pages in this handbook contain more detailed information on these subjects. The Poultry Water Quality Consortium is a cooperative effort of industry and government to identify and adopt prudent uses of poultry by-products that will preserve the quality of water for everyone.

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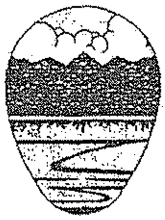

Dry Waste Management

A well-planned waste management system will account for all wastes associated with a poultry agricultural enterprise throughout the year, from the production of such wastes to their use. It is likely that the more integrated the waste management system is with the grower's other management needs, such as production, marketing, pest control, and conservation, the more profitable the farm will be.

Kinds of Poultry Waste — Manure and Litter

Poultry wastes are handled differently depending on their consistency, which may be liquid, slurry, semisolid, or solid.

The total solids concentration of manure depends on the climate, weather, amount of water consumed by the birds, type of birds produced, and their feed; it can be increased by adding litter or decreased by adding water. Thus, poultry waste systems can be either liquid or dry. Liquid waste management is explained in an additional fact sheet contained in this handbook (PWM-4).

Within the poultry industry, broiler, roaster, Cornish hen, pullets, turkey, and some layer operations are dry; live bird processing, some layer, and most duck and goose operations are liquid. In most dry operations, the birds are grown on floors covered with bedding materials. The manure collected from ducks, geese, and large high-rise layer operations is usually pure or raw manure, unmixed with litter. But it may be mixed with water during cleanout. Dry and liquid wastes require different collection, storage, handling, and management systems.

The amount of manure produced by a given flock of poultry can be roughly estimated from the amount of feed the birds eat. Table 1 can be used to estimate how much fresh manure and manure dry matter will be produced by various species and numbers of birds. Roughly, it is estimated that 20 percent of the feed consumed by poultry is converted to manure.

Litter

Manure mixed with a bedding material is called litter. The composition of litter varies, depending on how the chickens were fed, age and size of birds, the presence of moisture, the age and type of the litter itself, frequency of cleanout, and conditions of storage. Its composition can be estimated from analyses that have already been made on similar types of waste, but all litter should be analyzed at least once a year for nutrient content. Litter moisture in a well-managed house generally ranges from 25 to 35 percent. Higher moisture levels in litter result in greater weight and reduced levels of nitrogen.

Diminished productivity and income are the almost certain outcomes of an improper or failed animal waste management system. Good management has two goals: to reduce the production of litter and to make the best use of the litter that is produced.

How much litter is produced varies widely, depending on the producer's management style, feedstocks, number of cleanouts, climatic conditions, and bird genetics. However, broilers may produce up to one ton of litter per year per 1,000 birds, or about 81 cubic feet of litter for each 1,000 birds. The bedding materials, manure, and used feed in the litter have nutrient value for land applications, but may also be useful in other ways — for example, as a fuel source, as an ingredient in compost, or as beef cattle feed.

Table 1.—Approximate manure production by poultry.

1 Type of animal	2 Market or adult live wt/animal (lb)	3 Animals/ 1000 lb animal unit	4 Flocks/yr	5 Feed eaten /animal (lb/growing period)	6 Feed eaten /animal (lb/yr)	7 Manure dry matter produced (lb/yr /animal)[a]	8 Animals to supply 1 ton dry matter manure/yr[b]	9 Nutrient content of dry manure (lb/ton)[c] N	 P_2O_5	 K_2O
Layer[d]	4	250	1	77/52 wk	77	15.4	130	100	40-70	40
Layer, heavy	7	143	1	90/52 wk	90	18	111	—	—	—
Pullet[d]	3	333	2	15/20 wk	30	6	333	—	—	—
Broiler	4	250	6	9/7 wk	54	10.8	185	80	40-70	60
Roaster	7	143	4	18/10 wk	72	14.4	139	—	—	—
Turkey	20[e]	50	2	60/20 wk	120	24	83	100	40	20
Duck	7	143	6	19/7 wk	114	22.8	88	—	—	—
Guinea	3-4	285	1	18/18 wk	18	3.6	555	—	—	—
Pheasant	3	333	1	16/18 wk	16	3.2	625	120	40	50
Chukar	1.5	666	2	8/18 wk	16	3.2	625	—	—	—
Quail	0.5	2000	2	3/12 wk	6	1.2	1666	—	—	—

Note: Pounds of feed at 11 to 13 percent moisture x 0.20 = pounds of manure dry matter. Fresh manure is 75 to 80 percent moisture. Manure can be air-dried in the poultry house to as low as 15 to 25 percent moisture.
[a]Figure may vary with animal, ration, and season.
[b]Column 8 is obtained by dividing 2000 pounds by the value in column 7.
[c]Figure may vary plus or minus 50 percent, depending on animal, ration, and manure handling.
[d]Single Comb White Leghorn.
[e]Adult turkeys may vary from 12 to 36 pounds per bird live body weight.

Litter that is saturated with water is called cake. This litter must be removed from the house between flocks; it must be prevented from mixing with stormwater and becoming overly wet, and it must be dried to prevent odor. Good management practices will reduce the production of cake — for example, by checking for water leaks in the house and keeping the house at an even temperature.

Litter that has not become saturated in water can be left in the house between flocks. If the cake is properly removed from the house, total cleanouts can be delayed — sometimes for as long as two years or more.

Weight and volume of litter will depend on type of bedding material used, depth of bedding to start with, amount of cake removed or present, and length of time between complete cleanouts. The quality of litter depends on the method of removal, whether the material was raked or stirred between flocks, and manner and length of storage.

Outdoor or Open Range

Fields, pastures, yards, or other outdoor areas are used as ranges for chickens, turkeys, ducks, or game birds. Such areas must be located and fenced so that manure-laden runoff does not enter surface water, sinkholes, or wells. These operations may be required to have a discharge permit from the appropriate state regulatory agency.

Manure

The best method for managing manure depends on the type of housing used, dry or liquid collection, and the way the housing is operated. Misuse of poultry manure can reduce productivity; cause flies, odor, and aesthetic problems; and pollute surface and groundwater. Poultry manure can produce dust and release harmful gases such as carbon dioxide, hydrogen sulfide, methane, and ammonia. Fresh manure is troublesome if it gets too wet.

pack. Large amounts of soil increase the ash content and reduce the nutritive value of litter. Feed litter should be kept covered with polyethylene at least three weeks to ensure that sufficient heat is generated to kill pathogens.

Remember: storage is an interim step in waste management planning. It should be followed by nutrient management planning and appropriate use of the litter for land application.

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POULTRY WATER QUALITY CONSORTIUM
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Fresh manure can be handled in either dry or liquid form. Aerating or drying of manure requires ventilation. Ventilation can be achieved naturally (through proper housing design) or mechanically (through equipment). Aeration produces a low odor product of 15 to 25 percent moisture. Because it has less odor and weight, it is less expensive to haul, contains more nutrients, and can be stored more easily.

Liquid manure contains about 95 percent moisture and consequently weighs more than twice as much as dry manure. The trend within the industry is to avoid liquid waste handling operations and use the more convenient dry systems. Manure that is between 30 and 60 percent moisture is sticky, difficult to scrape, and more likely to break cleaning equipment.

Storage Facilities

Dry litter from broiler operations and dry manure from a layer operation are best stored under a roof or in covered stacks. These storage facilities have five essential features:

- sufficient capacity to hold the waste until it can be applied to land or transported off the farm,
- adequate conditions of temperature and humidity to permit storage of the waste until it is needed,
- a concrete or impermeable clay base to prevent leaching to groundwater,
- proper location to avoid runoff to surface waters or percolation to groundwater, and
- ventilation and containment for effective air quality and nuisance control.

Thus, the ideal storage design is a roofed structure with an impermeable earthen or concrete floor. This design keeps the litter dry, uniform in quality, and easy to handle; it also minimizes fly and odor problems. Management plans that allow for proper storage

- save water,
- improve bird quality,
- improve the production environment,
- reduce the amount of ammonia released from litter,
- reduce the volume of cake,
- extend the time between cleanouts,
- increase the product's value and flexibility, and
- prevent pollution of adjoining waters.

Kinds of Storage Facilities

Generally, storage facilities can be open, covered, or lined (permanently lined, in some cases); or they can be bunkers or open-sided buildings with roofs. Perhaps the most common facilities for collecting and storing poultry litter include floors, pits, dry-stack buildings, or covered outdoor storage facilities with impermeable earthen, or concrete flooring.

Floor Storage

Most broiler, roaster, Cornish hen, pullet, turkey, and small layer operations raise birds on earthen or concrete floors covered with bedding material (Fig. 1). A layer of wood shavings, sawdust, straw, peanut or rice hulls, or other suitable bedding material is used as a base before birds are housed. Wet litter — that is, cake — is removed after each flock. A complete clean-out can be done after each flock or once every 12 months or longer, depending on the producer's requirements. Slat or wire floor housing, used mainly for breeder flocks, can be handled the same way. Floor storage is the most economical method to store litter. Care must be taken not to leave foreign material such as wire, string, light bulbs, plastic, or screws in the litter.

Dry Stack Storage

Temporary storage of litter in a roofed structure with a compacted earthen or concrete floor is an ideal management method (Fig. 2). Large quantities of waste can be stored and kept dry for long periods of time. To prevent excessive heating or spontaneous combustion of wastes, stacks should not exceed 5 to 8 feet.

Table 1.—Approximate manure production by poultry.

1 Type of animal	2 Market or adult live wt/animal (lb)	3 Animals/ 1000 lb animal unit	4 Flocks/yr	5 Feed eaten /animal (lb/growing period)	6 Feed eaten /animal (lb/yr)	7 Manure dry matter produced (lb/yr /animal)[a]	8 Animals to supply 1 ton dry matter manure/yr[b]	9 Nutrient content of dry manure (lb/ton)[c] N	 P_2O_5	 K_2O
Layer[d]	4	250	1	77/52 wk	77	15.4	130	100	40-70	40
Layer, heavy	7	143	1	90/52 wk	90	18	111	—	—	—
Pullet[d]	3	333	2	15/20 wk	30	6	333	—	—	—
Broiler	4	250	6	9/7 wk	54	10.8	185	80	40-70	60
Roaster	7	143	4	18/10 wk	72	14.4	139	—	—	—
Turkey	20[e]	50	2	60/20 wk	120	24	83	100	40	20
Duck	7	143	6	19/7 wk	114	22.8	88	—	—	—
Guinea	3-4	285	1	18/18 wk	18	3.6	555	—	—	—
Pheasant	3	333	1	16/18 wk	16	3.2	625	120	40	50
Chukar	1.5	666	2	8/18 wk	16	3.2	625	—	—	—
Quail	0.5	2000	2	3/12 wk	6	1.2	1666	—	—	—

Note: Pounds of feed at 11 to 13 percent moisture x 0.20 = pounds of manure dry matter. Fresh manure is 75 to 80 percent moisture. Manure can be air-dried in the poultry house to as low as 15 to 25 percent moisture.
[a]Figure may vary with animal, ration, and season.
[b]Column 8 is obtained by dividing 2000 pounds by the value in column 7.
[c]Figure may vary plus or minus 50 percent, depending on animal, ration, and manure handling.
[d]Single Comb White Leghorn.
[e]Adult turkeys may vary from 12 to 36 pounds per bird live body weight.

Litter that is saturated with water is called cake. This litter must be removed from the house between flocks; it must be prevented from mixing with stormwater and becoming overly wet, and it must be dried to prevent odor. Good management practices will reduce the production of cake — for example, by checking for water leaks in the house and keeping the house at an even temperature.

Litter that has not become saturated in water can be left in the house between flocks. If the cake is properly removed from the house, total cleanouts can be delayed — sometimes for as long as two years or more.

Weight and volume of litter will depend on type of bedding material used, depth of bedding to start with, amount of cake removed or present, and length of time between complete cleanouts. The quality of litter depends on the method of removal, whether the material was raked or stirred between flocks, and manner and length of storage.

Outdoor or Open Range

Fields, pastures, yards, or other outdoor areas are used as ranges for chickens, turkeys, ducks, or game birds. Such areas must be located and fenced so that manure-laden runoff does not enter surface water, sinkholes, or wells. These operations may be required to have a discharge permit from the appropriate state regulatory agency.

Manure

The best method for managing manure depends on the type of housing used, dry or liquid collection, and the way the housing is operated. Misuse of poultry manure can reduce productivity; cause flies, odor, and aesthetic problems; and pollute surface and groundwater. Poultry manure can produce dust and release harmful gases such as carbon dioxide, hydrogen sulfide, methane, and ammonia. Fresh manure is troublesome if it gets too wet.

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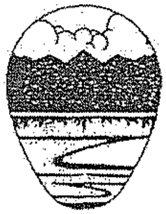

Liquid Waste Management

For ducks, geese, and some layer operations, manure is usually handled through liquid waste management systems. Water increases the amount of waste to be processed. Therefore, drying the manure naturally or through forced air systems as part of the collection and storage procedures can help control the amount of material to be managed.

A liquid waste system involves collection, storage, handling, and use. Collection and storage are generally combined into one operation that can include pits, settling tanks, or earthen storage ponds.

Advantages of a liquid waste management system are that it is easier to automate and less labor intensive. However, there are also disadvantages associated with liquid waste systems:

- constraints on management — must be emptied when full,
- costs — concrete can be costly or a grower may have insufficient land to construct a holding facility,
- toxic gases or unpleasant odors — these problems occur especially during waste removal,
- flies — insects will breed in improperly managed waste,
- volume — water vastly increases the amount of waste to be handled, and
- land applications of liquid wastes must be carefully planned and timed.

Volume comparisons between liquid and dry manure show that 10,000 caged layers produce nearly 2,500 pounds of manure per day, with an estimated volume of 50 cubic feet. In dry form, this manure weighs about 695 pounds, with 10 percent moisture, and reaches a volume of 27 cubic feet.

Most liquid waste systems require permitting by the appropriate state agency. Without the water, solid waste systems have less volume to control and lower equipment and energy costs. These considerations and operator preference help determine a particular grower's choice of poultry waste management systems.

Liquid Collection Methods

Most layer or pullet operations have cages arranged in up to four decks. The manure falls directly into a pit or is scraped into the pit from intervening dropping boards. Pits must be cleaned regularly, and the manure stored in concrete or steel storage tanks or applied directly to the land. A lagoon may be necessary to catch overflow. Ventilation fans are essential to keep the manure dry, and reduce toxic gases, fly problems, and offensive odors. Equipment is available for in-pit manure composting. There are three basic pit designs:

- Shallow-pit systems, built of concrete at ground level, are 4 to 8 inches deep and located 3 to 6 feet below the cages. Manure is scraped from the pit or flushed out with water and collected in a storage area or loaded directly into a spreader (Fig. 1).
- Deep-pit systems are usually 4 to 8 feet wide and may extend 2 to 6 feet below ground level with the cages at least 8 feet above the concrete or masonry floor. The pit floor and sidewalls must be sealed and thoroughly protected from outside surface

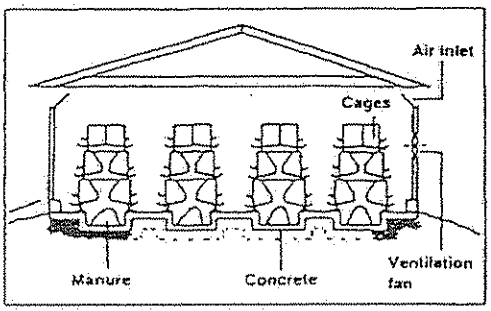

Figure 1.—Shallow-pit poultry house with cages.

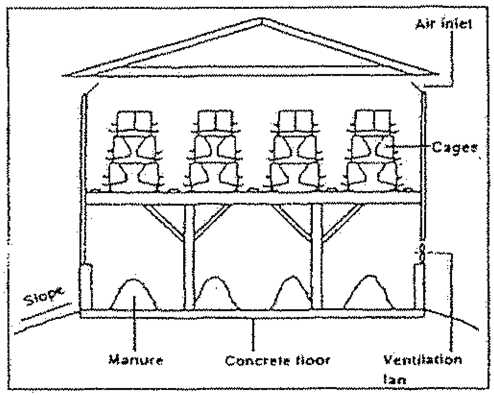

Figure 2.—High-rise poultry house with cages.

or groundwater. Foundation drains and external grading are needed to remove subsurface water and allow surface water to drain away from the building.

- High-rise systems are similar to deep-pit systems but are built entirely above ground, with the cages 15 to 30 feet above the ground (Fig. 2). The pit floor should be concrete and graded, with foundation drains. The water supply must be controlled if the wastes are stored for extended periods. If outside water penetrates the system, the manure can cause a serious fly problem or leach nutrients into surface or groundwater.

Settling Tanks

Concrete, concrete block, or steel storage tanks can be used to collect solids and to skim floating material from a layer operation. A floating baffle or other separator can be installed to remove egg shells, feathers, and other debris. The tank should be placed between the layer house and a waste storage pond or lagoon. Normally, a settling tank is 4 feet at the deep end, sloping to ground level. Walls are slotted to allow drainage of the settled waste.

It is recommended that two settling tanks be installed; one can be drained and cleaned while the other remains in operation. The tanks must be properly constructed and sealed to prevent groundwater or surface water pollution. In tanks and storage ponds, unpleasant odors and dangerous gases may be present and may require protective measures.

Storage Pond

A storage pond or lagoon is an anaerobic storage facility. It is designed to hold liquid waste from layer or other liquid waste operations. When the potential for groundwater contamination exists because of site conditions, the pond should be lined with clay, concrete, or a synthetic material. In warmer climates, structures are designed for a 30- to 90-day holding period but in colder areas, 180-day storage is needed. It is not practical to design a structure for less than 30-day storage. When the structure becomes full, it must be emptied, regardless of weather conditions. Specific criteria for construction of storage ponds can be obtained from the USDA Soil Conservation Service office.

Land Applications

Solid forms of manure are probably easier than liquid for land applications, but a manure slurry or irrigation system may be used. If the application falls directly on the crop, care must be taken to prevent ammonium toxicity and burning. Because raw manure contains high amounts of uric acid, it should be thoroughly mixed before application. Layer lagoon sludge is more dense than a pullet lagoon sludge because of its high grit or limestone content and should be diluted before application.

Timing is a major factor in successful land applications. The manure must also be uniformly applied — whether you are using a manure spreader or an irrigation system. The applicator should be particularly careful

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